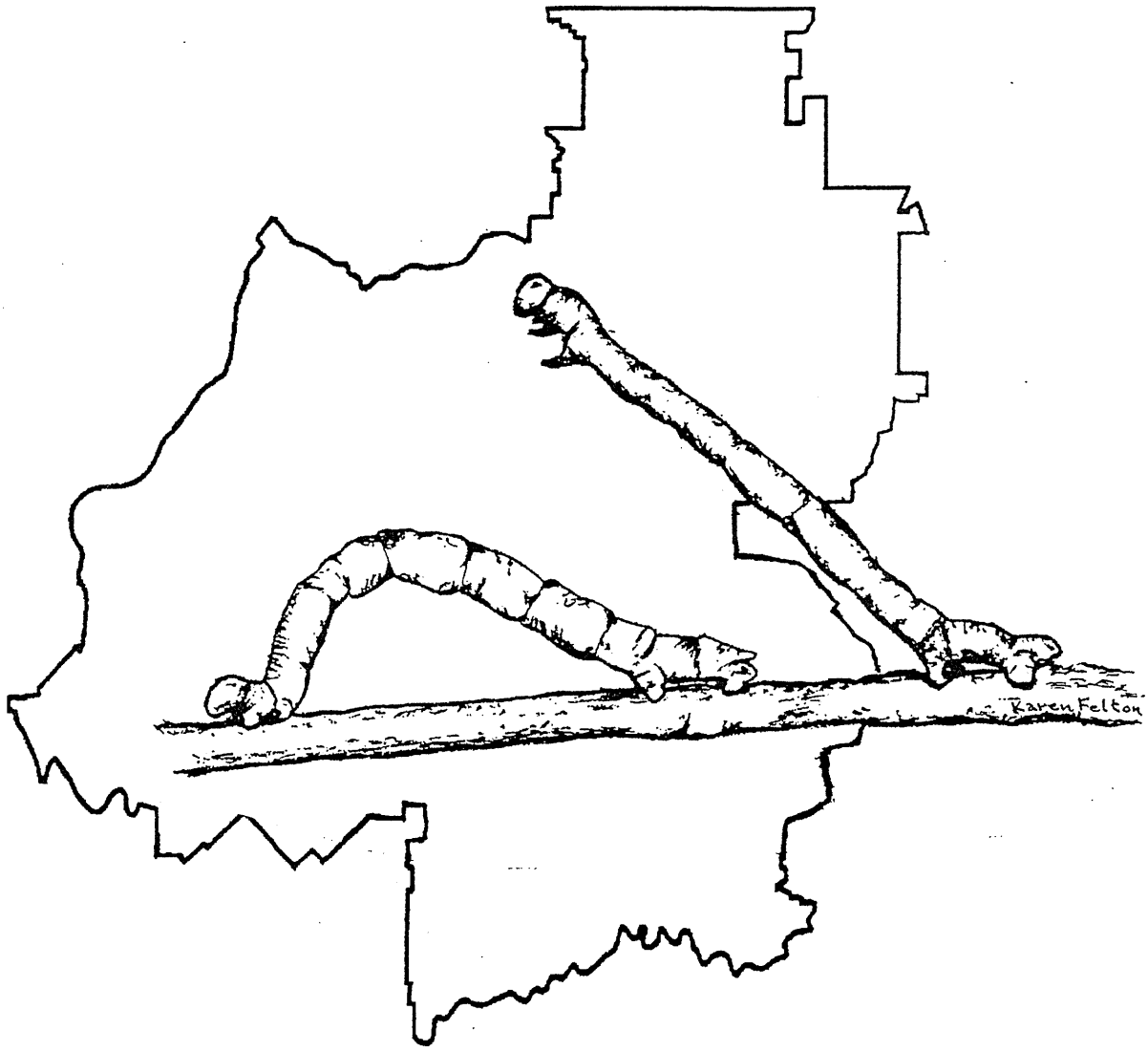
BIOLOGICAL EVALUATION OF ELM SPANWORM POPULATIONS, ALLEGHENY NATIONAL FOREST, PENNSYLVANIA 1993



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NORTHEASTERN AREA
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FOREST SERVICE
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DEPARTMENT OF AGRICULTURE

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SUMMARY

The elm spanworm, *Ennomus subsignarius* (Hubner), remained the major defoliator of the northern hardwood forests over much of the Allegheny National Forest in 1993. Over the last three years, elm spanworm defoliation has totalled 313,759 acres with 83 percent occurring in 1993 alone. Defoliation has been concentrated in American beech, sugar and red maples, and black cherry. Approximately 58,000 acres have received multiple years of elm spanworm defoliations since 1991. Recent elm spanworm egg mass surveys indicate a continuation of infestation in 1994 with moderate to severe defoliation predicted over most of the 1993 outbreak area. Natural control factors associated with wasp parasitism of elm spanworm eggs are expected to have only a minimal influence on the continuation of the current infestation.

Suppression of the elm spanworm infestation on 58,000 acres through aerial application of the microbial insecticide *Bacillus thuringiensis* variety *kurstaki* (*B.t.k.*) is recommended for 1994. *B.t.k.* spraying has a high probability of reducing defoliation and its impact on forest resources. Impacts include tree mortality and timber loss, increased nuisance to recreationists from larval presence and webbing, and reduced tree species diversity for wildlife and forest health. An assessment of *B.t.k.* effects on the non-target moth fauna and their wasp parasitoids in the sprayed areas is also recommended.

INTRODUCTION AND BACKGROUND

Much of the northern hardwood forests of the Allegheny National Forest (ANF) has been affected by an elm spanworm infestation which began in 1991. Over the last three years, elm spanworm infestations have defoliated a cumulative total of 313,759 acres (22,910 acres in 1991, 30,119 acres in 1992 and 260,730 acres in 1993). Map 1 shows the approximate 58,000 acres of visible elm spanworm defoliation during two or three consecutive years since 1991. Defoliation has been concentrated in American beech trees which often have been completely stripped of foliage. Where the infestations have been concentrated, sugar and red maples, and black cherry and other deciduous trees eventually also became defoliated.

Trees subjected to continued defoliation which removes most of their foliage are stressed through depletion of stored food reserves to replenish lost leaf surface for photosynthesis. Trees can become further stressed if drought conditions develop. Substantial tree mortality on parts of the ANF has resulted when outbreaks of another hardwood defoliatior, the gypsy moth, and drought have coincided. Major salvage sales within the oak type of the Sheffield, Bradford, Ridgway and Marienville Ranger Districts have resulted. Adverse effects of elm spanworm defoliation on the northern hardwood type of these ranger districts could lead to more changes in species composition, lost revenues through salvage and disruption of scheduled management opportunities.

Since the occurrence of unacceptable tree mortality in the oak type from gypsy moth infestations during the 1980s, there has been concern among ANF land managers as to how they could maintain the overall tree species diversity throughout the Forest under the threat of outbreaks from additional forest defoliators. In response to this concern, Forest Health Protection (FHP) has designed a survey which emphasizes collecting information on elm spanworm infestations most likely to cause the greatest risk to susceptible host types on the ANF.

OBJECTIVES

The objectives of this biological evaluation were: 1) to accurately assess current elm spanworm overwintering egg mass densities within the northern hardwood forest type of the ANF defoliated for two or three years since 1991; 2) to determine the likelihood that elm spanworm infestations would continue in these areas in 1994; 3) to determine the most likely impacts on ANF forest resources from a continuation of the current infestation; and 4) to develop treatment alternatives and recommendations.

ELM SPANWORM BIOLOGY

HISTORY OF INFESTATIONS

The elm spanworm periodically reaches outbreak populations in the eastern deciduous forests of the United States and Canada. During these outbreaks, most trees over large forested areas experience noticeable, and often complete defoliation, because this insect feeds on a wide variety of host species. Populations usually are at innocuous densities for many years or even decades before outbreaks develop. The imminency of an outbreak is indicated by the huge numbers of adults attracted to lights in and around the forest, which has been compared to a snowstorm during the summer.

The cause of elm spanworm population outbreaks probably relates to higher than normal survival because of abundant food and few natural controls. However, natural control factors, such as the two parasitoid wasps attacking the egg stage at different times (*Ooencyrtus ennomophagus* early, *Telenomus droozi* late), and late spring frosts denying larvae food, have always influenced the collapse of population outbreaks. Most outbreaks for which records exist have lasted from one to several years.

Infestations of elm spanworm have been infrequent in the northern hardwood forests of Pennsylvania, lasting for no more than a year. The current infestation on the ANF is an exception. Only two other infestations since 1950 have lasted as long or longer; an eight year infestation in the southern Appalachians and a three year infestation in Connecticut.

LIFE HISTORY

The elm spanworm has one generation each year, most of which is spent in the egg stage. Powdery white adult moths with a 1.5 inch wingspan emerge from pupae in late June and reach peak abundance early in July. Both sexes fly at night during this time, but the males are more commonly seen at lights than gravid females which usually remain on or near host trees. Eggs occur singly, but usually are deposited by the females in masses up to 250 on the underside of branches and the boles of trees. Egg masses are more common on rough bark trees and during outbreaks are more frequently found on the bole in or just below the tree crown. Larvae hatch from eggs as the leaves of their host are expanding and move directly to the young foliage where their initial feeding results in a shothole type of damage. As they mature, larvae feed on more of the leaf until only the midrib and petiole are left. During outbreaks, larvae consume or destroy leaves before they fully mature and are forced to move to other less preferred host trees in the area being defoliated. This movement of larvae often results in large quantities of silken threads being deposited throughout the forest canopy and understory. Those larvae that mature, complete their development by mid-June and pupate in a loose, silken cocoon attached to tree branches and boles or on the undergrowth.

NATURAL CONTROL FACTORS

All developmental life stages of the elm spanworm are influenced to some extent by parasites. Wasp parasitoids of the egg stage are considered the most important natural control factors contributing to the collapse of elm spanworm outbreaks. Two wasp species, *Telenomus droozi* Muesebeck and *Ooencyrtus*

ennomophagus Yoshimoto, have been identified; *O. ennomophagus* parasitizes eggs shortly after they are deposited and during the summer, and *T. droozi* the next spring shortly before they hatch. During the Connecticut elm spanworm infestation, *O. ennomophagus* destroyed over 99 percent of spanworm eggs on the lower and upper parts of the trees over large acreages of forest land. The wasp parasitoid *T. droozi* has been considered responsible for the collapse of elm spanworm outbreaks in other areas. Sixty percent egg parasitism by this wasp was found by Arnold Drooz to be the amount needed to cause an elm spanworm population collapse in Pennsylvania. In most outbreaks, an increase to this level of egg parasitism develops over more than one spanworm generation.

Parasites on third and subsequent instar larvae of the elm spanworm include the parasitoid wasps, *Meteorus* sp., *Apanteles murtfeldtae*, *Muscina stabulans* and tachinid flies. The following pupal parasites have been reported: *Brachymeria intermedia*, *Phagogenes mellinus* and *Aphanistes* species.

SURVEY PROCEDURES

ELM SPANWORM SAMPLING METHODOLOGY

Assessments of forest insect infestations provide forest managers with information about pest population trends, predictions of their damage to forest resources, and the status of natural control factors. Previously, forest pest management specialists have not had been involved with sampling elm spanworm populations because outbreaks of this species at the size and duration of the current infestation have rarely occurred. Sampling procedures for elm spanworm egg masses developed by Arnold Drooz, retired USFS entomologist, in oak forests of the southern Appalachians, were not considered applicable to the current infestation in the northern hardwood forests of the ANF. Rather, it was necessary to devise a sampling procedure to evaluate current populations densities and infestation trends specific to this fores type. The following methodology was developed to incorporate some of the findings and recommendations in the procedure used by Ed Simmons, PA-BOF, FPM Staff, in 1993.

Oviposition preference of the elm spanworm females in Pennsylvania appear to be in sheltered areas of large codominant trees. These areas include the underside of branches, behind bark flaps, and/or any other sheltered areas under roughened bark on tree boles. Most egg masses were found 30-70 feet above the ground. The eggs are very small and brown. Each is laid singly or in masses up to 250. During infestations, new eggs are often deposited in layers either over old egg masses or even new ones. Because the eggs are difficult to see in the upper bole, it was necessary to use a destructive sampling method to obtain data. Rough barked trees were felled to facilitate the collection of accurate egg mass data and information on the status of wasp parasitoids.

The potential for elm spanworm infestations to continue damaging forests in parts of the ANF in 1994 was determined by sampling elm spanworm egg masses on trees in those areas which had been defoliated for two and three years since 1991. These areas had been identified from aerial sketchmaps and/or airborne videography obtained annually by John Omer, FHP, Morgantown. The trees selected for ground sampling were rough bark species, usually black cherry, *Prunus serotina* Ehrh., or red maple, *Acer rubrum* L., in a codominant position within the stand. The following site and tree data were obtained for each tree selected: 1) height, diameter, age, and species; 2) species composition of the codominant trees for the stand immediately around the site; and 3) slope and aspect of the sample area. The selected trees were felled and all egg masses counted. Subsamples were taken to determine the ratio of new egg masses to old ones. Several egg masses were collected for later analysis of population densities of the egg parasite *Ooencyrtus ennomophagus*. No analysis of the egg parasitoid *Telenomus droozi* could be made because this species attacks the egg stage just prior to hatch in the spring. The wasp parasitoids of the elm spanworm will be monitored during 1994 as part of the non-target species assessment to determine spray effects on inverterbrate biodiversity.

Field Procedures for Sampling Newly Deposited Elm Spanworm Egg Masses
Developed by John Omer for the Allegheny National Forest, Winter 1993/1994

-select a sample site from within the areas defoliated by elm spanworm
-observe and record the slope and aspect of the sample site
-observe and record the species composition make up of the codominant trees in the stand where the sample site is located
-select a codominant tree in the sample area
-preferably choose a rough bark species (black cherry, red maple, oak, etc.)
-count and record all egg masses on the butt log section, below 6 feet
-large areas of bark covered with egg masses deposited by many females should be partitioned to estimate the number of egg masses by using a dime to represent the average size of a single egg mass
-measure and record tree DBH
-cut down the tree
-measure and record total tree height (to the nearest foot) by pacing along its length
-count and record all egg masses on the section from 6 feet to the beginning of the crown, this section will need to be cut and rolled to count all sides
-count and record all egg masses found in the crown
-randomly select two, one square foot areas on opposite sides of the tree, just below the crown and count and record all old as well as new egg masses to establish the population trend based on ratio of new to old egg masses
-collect 1-2 egg masses from about one-third of sample sites, keep them separate and send them to FHP, Morgantown, to count portion of 500 eggs per site parasitized by *Ooencyrtus*
-cut a disk of wood from the lower end of the butt log of the felled tree and take this to the office to count rings and determine tree age

RESULTS

Table 1 summarizes data by administrative unit for the 52 sites sampled in 1993. Map 2 shows the locations of the sample sites/trees on each Ranger District/Experimental Forest where the elm spanworm egg mass were sampled. Except for the higher egg mass densities on the Kane Experimental Forest, elm spanworm populations were between 973 and 1,527 per tree on all four Ranger Districts surveyed. The ratio of new to old elm spanworm egg masses forest-wide in 1993 averaged 7.2.

Table 1. 1993 Elm Spanworm Egg Mass Survey Results, Allegheny National Forest, PA

Adm Unit, Ranger Dist/ Exper Forest	Number of Sample Trees	Average Tree DBH (in.)	Average Tree Ht. (ft.)	Number New Egg Masses per Tree	Ratio New/Old Egg Masses
Bradford	11	16	76	1,126	4.3
Marienville	16	14	85	973	5.1
Ridgway	18	16	90	1,458	11.6
Sheffield	4	18	72	1,527	8.5
Kane Exp For	3	25	85	3,190	6.3

Egg parasitism by wasp parasitoids was evident in five of the sixteen sites sampled. Parasitism by *Ooencyrtus ennomophagus* amounted to less than one percent of the 8,000 elm spanworm eggs examined in the laboratory.

DISCUSSION

Surveys of elm spanworm egg masses during the 1993-1994 autumn and winter indicate the presence of even more abundant, healthy elm spanworm populations for the current generation on the ANF than that which caused widespread defoliation to the northern hardwood forests in 1993. Not only did elm spanworm egg mass densities increase more than seven-fold, but less than 1 percent of the eggs were found to be parasitized by *Ooencyrtus ennomophagus*, the wasp parasitoid predominant during the summer and into the fall. No information currently is available about the other wasp parasitoid, *Telenomus droozi*, whose adults attack elm spanworm eggs shortly before they hatch. Sixty percent egg parasitism by this species has been associated with elm spanworm population collapse in outbreaks that have occurred in Pennsylvania and the southern Appalachians. If this percentage of elm spanworm egg parasitism is needed for population collapse, it highly unlikely that it will occur this spring. In all other infestations, this level of egg parasitism developed in more than one spanworm generation.

Because of the increasing population trend found throughout areas of the ANF in 1993, widespread defoliation of American beech and maples is anticipated again in 1994. This defoliation can cause added stress to tree health depending upon what portion of the foliage is consumed. Trees that are defoliated in excess of 40 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, branch dieback or in some cases tree mortality, are likely to occur following a single year of heavy defoliation. Should defoliation occur again the following year, the impact is compounded. Trees that receive light-moderate defoliation (<40 percent) generally will not refoliate and there is probably no significant impact other than some reduction in growth.

Aerial suppression should be considered in FY 1994 because: 1) elm spanworm populations densities have increased several times above the previous year's level; 2) additional defoliation of northern hardwoods is anticipated over large portions of the ANF in 1994; 3) tree mortality could potentially occur in areas defoliated for several years; 4) impacts of tree mortality could influence species diversity, timber production, and recreational activities in the areas where the infestation is concentrated.

TREATMENT ALTERNATIVES

NO ACTION

If the no action alternative is chosen, the potential exists for moderate to severe defoliation and nuisance larval populations during June 1994 in much of the ANF. The result of another year of defoliation in those areas with three and four consecutive years of similar damage would probability result in concentrated areas of tree mortality in the most susceptible host trees. Because wasp parasitism is very low, it is unlikely that this natural control factor will have much influence on the infestation in 1994. Furthermore, it is likely that elm spanworm population densities will intensify and expand to currently uninfested areas in the northern hardwood forests of the ANF in 1995.

USE OF MICROBIAL INSECTICIDE

Microbial insecticides can be effectively used to reduce elm spanworm populations. The only biological insecticide currently registered and commercially available for elm spanworm control is *Bacillus thuringiensis* variety *kurstaki* (*B.t.k.*) at 6 to 16 billion international units (BIUs) per acre. *B.t.k.* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major

mode of action is mid-gut paralysis which occurs soon after ingestion causing a cessation of feeding and death by starvation.

There have been few operational spray projects against elm spanworm outbreaks. In a 1973 project in Connecticut, *B.t.k.* at 12 BIUs per acre in a single application effectively killed elm spanworm larvae within a few hours after it was sprayed. With proper timing of the application to reach first to third instar larvae before noticeable defoliation occurs, foliage protection and a high degree of population reduction can be expected with one application. Therefore, a single application of *B.t.k.* at 12 BIUs/acre would be recommended to achieve significant population reduction and protect forest resources. The actual degree of population reduction would not be expected to vary much if ideal spray conditions prevail, but delays in spraying and poor spray weather (rain and high temperatures above prescribed thresholds to ensure adequate deposition) could decrease spray deposition on foliage and alter results from those discussed here.

RECOMMENDATIONS

FHP recommends the ANF consider the aerial suppression alternative.

Potentially damaging elm spanworm populations exist within those areas of the ANF defoliated for two or three years since 1991. The forest stands in the areas potentially affected by the elm spanworm are managed for tree species diversity, timber, and recreation. Basically, the ANF managers have two alternatives:

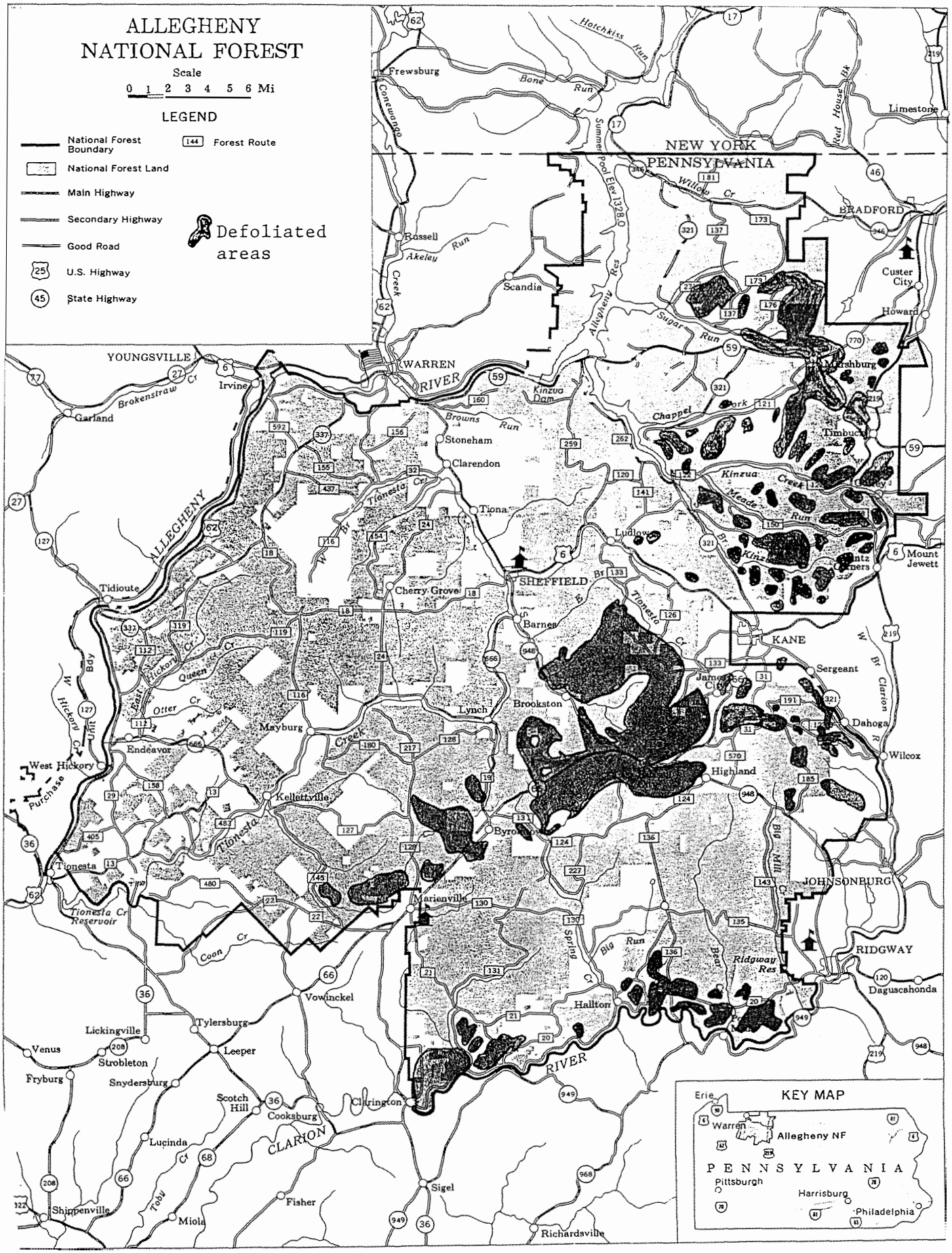
1) no action
2) aerially spray in selected areas the registered microbial insecticide *B.t.k.* to prevent nuisance, defoliation, and subsequent tree mortality

If the no action alternative is chosen, the potential exists to continue the moderate to severe defoliation in numerous areas across the ANF. Resulting mortality has the potential to interfere with management by accelerating tree mortality rates in the northern hardwood forest type.

By chosing the suppression alternative, the ANF forest resource values such as recreation, timber, and tree species diversity would receive maximum protection by suppressing elm spanworm populations in areas that have experienced several years of defoliation.

FHP also recommends that the ANF conduct non-target monitoring. Non-target moths and wasp parasitoids of the elm spanworm and other Geometridae should be monitored at the same site the year of spraying and during the following year to assess spray effects on invertebrate biodiversity in the northern hardwood type of the ANF. This information could provide a better understanding of where and how to sample for the wasp parasitoids *Ooencyrtus ennomophagus* and *Telenomus droozi* such that their effects on elm spanworm infestation populations can be better assessed. Currently, wasp parasitoids of the elm spanworm are inadequately sampled. Management decisions about the influence of parasitism on populations of this and other forest defoliating Geometridae need to be improved so that suppression is both timely in anticipation of outbreaks and naturally collapsing outbreaks are not sprayed.

Map 1. Elm Spanworm Defoliation, Multiple Years from 1991-1993.



Map 2. 1993 Elm Spanworm Sample Site Locations.